

Inferential Sensing Solution: Artificial Cerebellar Intelligence™

1. The Problem – Predictive Maintenance

Relative to safety, reliability, and adaptive control objectives, complex machines are generally *underdetermined estimation problems*. Such problems are analogous to algebraic systems having more unknowns than equations, resulting in mathematical intractability for a unique solution. Most organizations do not realize that this underlying problem bars many of the predictive maintenance methods of their engineers and providers, particularly when degradation modes are subtle, complex, or diverse. When your complex machine behavior depends on more unmonitored independent time-varying attributes (e.g., degradation modes) than it has independent outputs utilized by the inferential sensor, then the math will not support accurate estimations of the time-varying attributes, particularly if highly nonlinear physics govern the time-varying attributes. Even the math that is implicit in heuristic methods, empirical algorithms, and logic protocols, including state-of-the-art utilizations of neural networks in their many AI formulations, must fail in such conditions. Practical solutions may classify enough potentially time-varying attributes as time-invariant for a useful operational period and then utilize inferential methods and scheduled maintenance that work under such assumptions. This can be routinely costly when the safe operational period is highly conservative, and seriously costly when assumed constant system attributes do not cooperate. In some cases, organizations spend an enormous amount of money and time chasing red-herring predictive-maintenance solutions that can never be reached due to the underlying mathematical barrier imposed by an underdetermined system.

Consequentially:

- Costly and catastrophic failure modes can linger in machines, remaining unobserved until the failure happens.
- Machine health is managed by overly conservative periodic teardowns, at relatively high cost to production.
- Advanced process control outcomes remain out of reach.

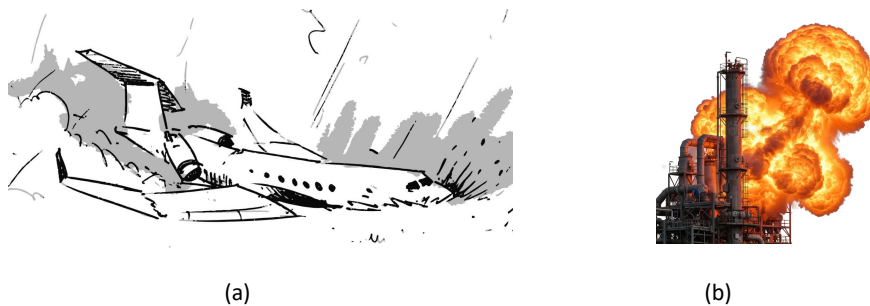
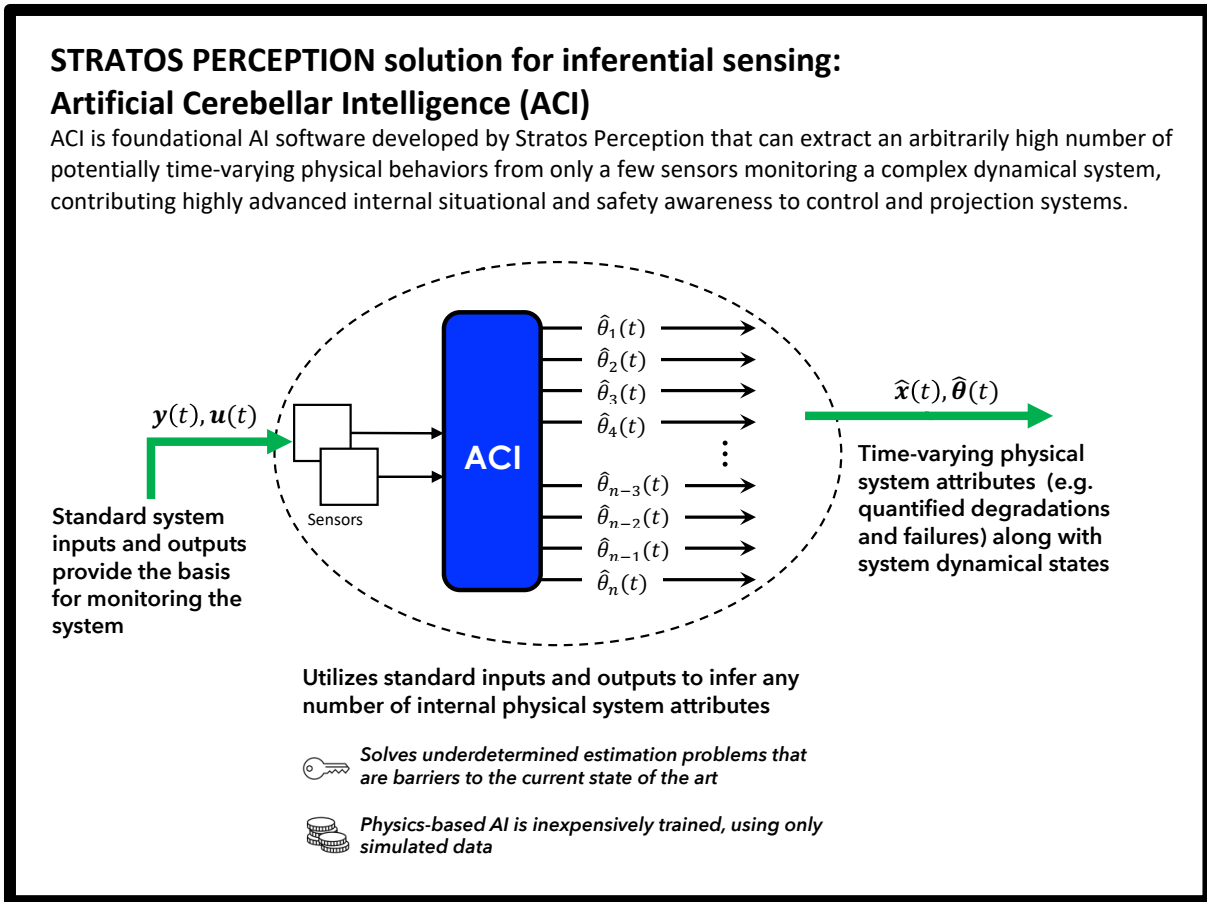


Figure 1. Illustrations of consequences of unmonitored failure modes: (a) crashed commercial airliner, (b) refinery fire

2. Revolutionary Artificial Intelligence Solution – Artificial Cerebellar Intelligence

Stratos Perception has developed a revolutionary new paradigm in inferential sensing that is a general solution to underdetermined highly nonlinear dynamical systems. Our solution is differentiated from other solutions because it directly solves the historically intractable underlying underdetermined estimation problem for complex dynamical systems. We call the solution *Artificial Cerebellar Intelligence (ACI)*. ACI can infer, in real-time, and in first-principles terms, the values of hundreds of time-varying attributes of a complex dynamical system, based on the comparatively few standard inputs and outputs. This comprehensively informs control and protection systems, enabling them to adapt to degradations and failures and to perform system-optimized operations that may have otherwise required operator support. Because the ACI is physics-based, the training its algorithms requires only synthetic data normally acquired from first-principles software models. Limited actual system operational histories are required for testing and validation.



3. Differentiation

- **Enterprise Solution and ROI:** Other methods for predictive maintenance and fault tolerance are incremental technologies without a clear path to solving your problem at an enterprise level because they are limited by underlying mathematical realities. ACI is revolutionary because it directly solves the underlying underdetermined adaptive estimation problem to provide a powerful solution that is generalized and directly applicable to machines and processes across your enterprise.
- **Higher Income and Lower Losses:** ACI can exponentially increase the internal system information available to control and protection systems, including to other AI implementations and to operations people, to dramatically reduce opportunities for costly accidents and to optimize product yields.
- **Rapid Development and Engineer Friendly:** An ACI application can be developed in a few weeks and scales immediately to the fleet. The ACI solution can be provided as a cloud-based API or a local library, to integrate with machines as well as model-based systems engineering systems.

4. Action

We are seeking commercial partnerships and investments. Let's start a relationship with a mutual nondisclosure agreement. We are interested to collaborate in the accelerated engineering and development of ACI into system solutions. ACI and several of its implementations are patent-pending technologies that are available for license, purchase, and co-development.

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